Implicit Space-Time Distortion through a Mass Field

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Fuck you, Epik Schweinberg

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Space
Space - is emptyness.
A "coordinate system" is a frame, a scaffolding to map out this emptyness.
The "coordinates" are "tags" that one puts on the frame.
A "reference" frame is the frame I "refer" to and as such **it never moves**!
They had to threaten Galilei with torture to stop talking nonsense on that subject.
In physics, the reference frame serves to formulate laws of motion. Depending on which frame I use and whether they move **relative to each other**, these laws will differ.

Laws of motion imply *lengths*. The "tags" become the number of "meter sticks" of whatever nature.
The simplest reference frame that one can come up with is a cubic grid of identical rigid cubes bolted together. "Identical" meaning, all constructed as the copy of one single cube.
We will call this the *Identical Frame*.
We are, however, not limited to the Identical Frame but can map out space at our fancy as long as we can tag positions numerically and continuously.

Time
Laws of motion imply *time*. Time, of course, means clocks.
Contrary to the spatial frame which can come in any shapes and sizes, with identical or non-identical meter sticks, for the clocks we have no option: they must all be SYNCHRONIZED.
When one clock emits ticks received by a second clock, this clock's ticks must be in lockstep with the ticks of the first clock.
The requirement for synchronisation ensures that the time variable be *differentiable*.
If we had unsynchronizd clocks, then two clocks no matter how near would acquire a finite time difference which makes it impossible to define a *speed* by time differentiation.

Mass and Metric
Our current metric system has been developed alongside the formulation of our laws of motion.
It relies on quantum mechanics and the speed of light. The necessary constants are: the speed of light, Planck's constant and a quantized resonance frequency.
The frequency together with the speed of light gives the length of the meter stick.
The frequency with Planck's constant gives the energy and thus MASS.
Hence, the quantized frequency is the heart of the metric system and provides this system's clocks.
When one looks at the quantized frequencies, it turns out that they are all proportional to elementary particle MASS (epm).
If we had two clocks (1,2) of which 2 has epm twice as much as 1, then all its quantized resonances have *twice* the frequencies of 1 and all scales have *half* the scales of 1.
Mass makes measures ("Masse macht Maβe")

WITHOUT MASS THERE IS NO MEASURE!!!

We can go so far and take the mass of an elementary particle as reference frequency. This is perfectly equivalent to taking any atomic clock.

This will from now on be our *IDENTICAL CLOCK* which we can carry around.

Mass field
From what we just said, it becomes clear that tinkering with mass by the introduction of a "mass field" will have repercussions on the metric system.
Let us become specific and formulate a Lagrangean formalism using the Dirac equation with a scalar mass field.
We limit ourselves to one kind of elementary particle explicitely. All other particles are coupled in the same way with a constant of proportionality proper to each species.
Electromagnetic interactions are taken into account through the Green-function Lagrange term.
The scalar mass field coupling will be of the form Φ^2 , not linear since this would require a justification through covariant derivatives.

$$L=\int dt\, d^3x \left(i\,\overline{\psi}\,\gamma^{\mu}\,\partial_{\mu}\psi+\alpha\frac{1}{2}\overline{\psi}\,\gamma^{\mu}\,A_{\mu}\psi+\phi^2 m_e\,\overline{\psi}\,\psi\right)$$

We get the usual Dirac-equation

$$\left(i\,\gamma^{\mu}\,\partial_{\mu}\psi+\alpha\,\gamma^{\mu}\,A_{\mu}\psi+\phi^2 m_e\,\psi\right)=0$$

The coordinates (x,y,z) correspond to the number of "meter sticks" in the respective direction.
We have spatial isotropy, meaning that the meter sticks are the same for each direction.
The time variable (t) is the number of ticks of a clock at the respective place.
All clocks are synchronized among them.
The meter sticks correspond to a defined number of ticks of the synchronized clock times the speed of light.

Gedankenexperiment
Let us suppose a static mass field with two large plateaux (1,2) at Φ(1) and Φ(2).
There cannot be any force actions from the mass field within a plateau since it is everywhere the same there.
Let us create a gamma ray at the particle's mass from (1) to (2)
The paricle mass frequency in (1) is

$$\omega(1)=\Phi^2(1)m_e$$

This gamma ray now travels to plateau (2).
It keeps its frequency since the mass field does not act on the electromagnetic field.
Upon arrival in (2), one compares this frequency with the mass frequency of an elementary particle in (2)

$$\omega(2)=\Phi^2(2)m_e\neq\omega(1)$$

What does that mean?
The frequency emitted by an identical clock in (1) does not match the frequency of an identical clock in (2).
But wait a minute! Who is then the timekeeper?
To which clocks does the variable (t) refer to?
Since identical clocks are out of sync between (1) and (2), the synchronized clocks must be NON-IDENTICAL clocks!
Let's go further: The electromagnetic term is unchanged and contains the speed of light.
Thus, together with the synchronized clock frequency, we get the length of the meter stick.
Since synchronized clocks turn out to be nonidentical, meter sticks will also be NON-IDENTICAL!
Their length, as compared to an identical meter (one that can travel around) will depend on location.
The frame that we thought to be a rigid Identical Frame turns out to consist of nonidentical meter sticks and will unavoidably be deformed compared to an Identical Frame.
This is the "Implicit Space-Time Distortion" advertised in the title.

Frames
The frame that we use in the Dirac equation corresponds to a material scaffolding with non-identical meters due to the varying mass field.
The metersticks are created using synchronized clocks and we will call this frame the *Synchronized Frame*.
Let us find its relation to an Identical Frame.
For this, we first have to find the relation between an identical clock and a synchronized clock.
Identical clocks in High-Φ regions are blue-shifted with respect to those in Low-Φ regions.
Synchronized clocks must then be detuned in the opposite way.
The number of ticks (dτ) of an identical clock at one place **r** is then given by the number of ticks (dt) of a synchronized clock and the Φ-field at that place through

$$d\tau=\Phi^2(\vec{r},t)dt$$

Recall that the identical clocks are not synchronized, otherwise the number of ticks would be the same.
The correlation between the number of synchronized metersticks dx and identical metersticks dκ is of the same form

$$d\kappa=\Phi^2(\vec{r},t)dx$$

This means that synchronized meters in High-Φ regions are lengthened and those in Low-Φ regions are shortened.

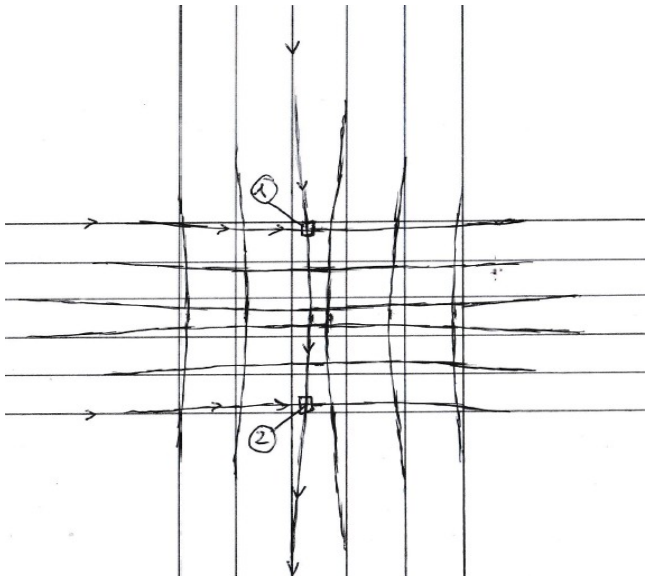
We can construct the Identical Frame (IF) from the Synchronized Frame (SF).
We are entitled to have IF and SF coincide at one place in length and orientation.
Let us also choose this place to be the common zero of coordinates.
Spatial vectors in the IF are obtained by integrating the differential relation above

$$\vec{\kappa}(\vec{R}) = \int_0^{\vec{R}} \Phi^2(\vec{r}, t)\, d\vec{r}$$

The path of integration is a straight line.

Finally, as far as the force action of the mass field is concerned, particles will be driven from high-Φ to low-Φ regions.
This way, we can sketch a SF relative to an IF for an attractive sphere.
Close to the sphere, we are in low-Φ domaine and have shortened synchronized meters.
Far away, SF and IF approach each other.

figure 1: straight line: IF, bent lines: SF



Star Gazing

We have already mentioned that light propagation in the SF is unmolested by the mass field.
Hence, light follows straight lines in the SF.
Let us observe two stars under an angle (90° for convenience), with the observer once in front of the attracting sphere (the Sun) (1), once behind it (2).
The relative angle of the stars will be strictly the same.
Since we can choose to have IF and SF coincide there, an observer on earth will see no starlight deflection past the Sun.
It is not often that a prediction is - nothing.

On Earth

If we cannot map out the Universe, we can map out Earth or at least our laboratory.
This is the famed "Laboratory Frame" which is usually an Identical Frame.
Before transforming our Dirac Lagrangean to the IF, a few remarks are in order.

- the mass field ensures that we can set up a metric *at all*.
We therefore require that

$$\Phi^2 > 0 \quad \text{or} \quad \Phi^2 = e^{\lambda}$$

We will use this expression from now on.

- the time variable must correspond to synchronized clocks in any frame, be that SF or IF.
We therefore must leave the time variable untouched.
If we want to calculate forces in the IF, we will express derivative with respect to identical clocks as

$$\frac{d}{d\tau} = \frac{d}{e^{\lambda} dt}$$

- the change of frame does not change the resultant equations of motion, since the mass field is a given and the mapping between SF and IF is reversible.
So, we are entitled to directly perform our variation procedure in the IF, rather than to cumbersomely transform the result from SF to IF.

In the transformation process, we substitute the SF-differentials by their IF forms (see above) and absorb their inverse to equal parts by
- the wavefunction

$$\psi \rightarrow e^{-\lambda} \psi$$

- the conjugate wave function

$$\overline{\psi} \rightarrow e^{-\lambda} \overline{\psi}$$

- the derivative

$$\frac{d}{d\vec{r}} \rightarrow \frac{d}{e^{\lambda} d\vec{r}} = \frac{d}{d\vec{\kappa}}$$

- the EM Greenfunction

$$\vec{A} \rightarrow e^{-\lambda} \vec{A}$$

- we leave, as already said, the time variable untouched which leaves

$$\frac{\partial}{\partial t} \rightarrow \frac{\partial}{e^{\lambda} \partial t}$$

The Green function transformation deserves some mention.
It is of the form

$$\frac{1}{2}\int dtd^3x\,dt'd^3x'\,\overline{\psi}(\vec{r},t)\gamma_k\psi(\vec{r},t)G(\vec{r}-\vec{r}',t-t')\overline{\psi}(\vec{r}',t)\gamma^k\psi(\vec{r}',t)\rightarrow$$
$$\frac{1}{2}\int dtd^3\kappa\,dt'd^3\kappa'\,\overline{\psi}(\vec{\kappa},t)\gamma_k\psi(\vec{\kappa},t)e^{-\lambda(\kappa,t)}G(\vec{r}-\vec{r}',t-t')e^{-\lambda(\kappa',t')}\overline{\psi}(\vec{\kappa}',t)\gamma^k\psi(\vec{\kappa}',t)$$

The original space vectors **r, r'** become functions of the mass field.

$$\vec{r}(\vec{\kappa},t)=\int_0^{\vec{\kappa}} e^{-\lambda(\kappa,t)}d\vec{\kappa}$$ (path of integration is, again, a straight line)

The time derivative becomes the only term where the mass field is still explicitely present in the field equations.
The mass field is also present, albeit in a more hidden form, in the EM Greenfunction, indicating light bending in the Identical Frame.
This comes as no surprise. We already saw this in our sketch of IF and SF.
The Dirac equation in the IF is trivially

$$(i\,e^{-\lambda}\gamma^0\partial_t\psi+i\,\gamma^j\partial_j\psi+\gamma^\mu A_\mu\psi+\phi^2 m_e\psi)=0$$

The only dynamical equation that we are interested in is the force action of the mass field on particle momentum given by

$$\vec{p}=\frac{1}{2}(i\,\overline{\psi}\gamma_0\nabla\psi+h.c.)$$

The force is momentum change per time of an *identical clock*

$$\vec{F}=\frac{\partial}{\partial\tau}\vec{p}=\frac{\partial}{e^\lambda\partial t}\vec{p}$$

Leaving all terms aside except the mass-field one, we get

$$\vec{F}=\frac{\partial}{\partial\tau}\vec{p}=\frac{\partial}{e^\lambda\partial t}\vec{p}=(\nabla\lambda)\frac{1}{2}(i\,\overline{\psi}(\gamma_0\frac{\partial}{e^\lambda\partial t}\psi)+h.c.)$$

The force action is proportional to the total particle energy.
This is, of course, the phenomenology of gravity.

The actual acceleration (g) is the gradient of the, dimensionless, exponent function λ times c^2.
or $\nabla\lambda=\frac{g}{c^2}$.
We recall that synchronized clocks are non-identical and identical clocks are detuned as e^λ related to this force action. (Möβbauer experiments)

This all comes as a surprise to no one.

Mass Field Equations

The Lagrangean of the mass field as a simple scalar field is assumed to be (up to a coupling constant) (c=1)

Set $\Phi^2 = e^{\lambda}$

$$L = \int dtd^3x \frac{1}{2}[\dot{\Phi}\dot{\Phi} - (\nabla\Phi)(\nabla\Phi)] = \int dtd^3x\, e^{\lambda}\frac{1}{8}[\dot{\lambda}\dot{\lambda} - (\nabla\lambda)(\nabla\lambda)]$$

Variation of λ

$$e^{\lambda}([\dot{\lambda}\dot{\lambda} - (\nabla\lambda)(\nabla\lambda)] - 2[\dot{\lambda}\dot{\lambda} - (\nabla\lambda)(\nabla\lambda)] - 2[\partial_t^2\lambda - \nabla^2\lambda]) = RHS$$

$$e^{\lambda}(-[\dot{\lambda}\dot{\lambda} - (\nabla\lambda)(\nabla\lambda)] - 2[\partial_t^2\lambda - \nabla^2\lambda]) = RHS$$

Here we use the *Synchronized Frame*.

We are, à priori, *not* entitled to do the variation procedure in the Identical Frame since the mass field still has to be determined by said procedure.
If we did, we would end up with different field equations which cannot be transformed into each other.
In order to see whether the equations just derived give a reasonable description of gravity, let us look for stationary solutions with radial symmetry and only a central source (RHS = 0)

$$(\frac{1}{2}[(\nabla\lambda)(\nabla\lambda)] + [\nabla^2\lambda]) = 0$$

Set $y = \frac{d}{dR}\lambda$

$$y' + \frac{2}{R}y + \frac{1}{2}y^2 = 0$$
$$\frac{y'}{y^2} + \frac{2}{Ry} = \frac{-1}{2}$$

Set $f = \frac{1}{y}$

$$\frac{-d}{dR}f + \frac{2}{R}f = -1/2$$

The general solution is one specific solution plus any solution of the homogeneous equation

Specific solution

$$f_s = \frac{-R}{2}$$

Homogeneous solution

$$\frac{-d}{dR} f_H + \frac{2}{R} f_H = 0$$

$$f_H = aR^2$$

$$f = f_s + f_H = aR^2 - \frac{R}{2}$$

$$y = \frac{d}{dR}\lambda = \frac{1}{R(aR - 1/2)} = \frac{-2}{R} + \frac{2}{(R - 1/2a)}$$

$$\lambda = -2\ln\left(\frac{R}{R_0}\right) + 2\ln\left(\frac{R - 1/2a}{R_0 - 1/2a}\right)$$

$$e^{\lambda} = \frac{R_0^2}{R^2}\frac{(R - 1/2a)^2}{(R_0 - 1/2a)^2}$$

$$\lambda' e^{\lambda} = \frac{R_0^2}{R^2 aR}\frac{(R - 1/2a)}{(R_0 - 1/2a)^2}$$

If the force F is known at R_0 then

$$F = \lambda' e^{\lambda}(R_0) = \frac{1}{aR_0(R_0 - 1/2a)} \quad \rightarrow \quad a = \frac{1}{R_0^2}\left[\frac{1}{F} + \frac{R_0}{2}\right]$$

For an attractive force at R_0 , $F > 0$ and always $a > 0$
For a repulsive force at R_0 , $F < 0$ and we can have $a > 0$ or $a < 0$

For $a < 0$, one only gets repulsion.
For $a > 0$: As long as $R > 1/2a$, $\lambda' > 0$ and we have attraction towards the center.
However, if $R < 1/2a$, $\lambda' < 0$ and we have repulsion from the center.
At $R = 1/2a$ the mass field becomes zero which is an anomaly since one always has $e^{\lambda} > 0$.
At R=0, the mass field diverges non-integrably. That means that we cannot construct an Identical Frame anymore.

Well, not really a simple, straightforward behaviour.

We might "fix" it by requiring that the solutions be transferable to an IF.
For the attractive solution (a > 0, R > 1/2a), one can invoke a non-zero RHS for R < 1/2a, set the mass field to a near-zero value there, which will collapse the sphere in the SF to practically a point in the IF.
For the repulsive solution (a < 0), one just excludes the origin with a tiny radius R > 0 to account for the non-zero RHS.

Identical Frame

Instead of starting from the Synchronized Frame, we can transform the Lagrangean to the Identical Frame to get *different* equations (see remarks above)

$$L = \int dtd^3x \frac{1}{2}[\dot{\Phi}\dot{\Phi} - (\nabla\Phi)(\nabla\Phi)] \rightarrow \int dtd^3\kappa \frac{1}{2}[e^{-2\lambda}\dot{\lambda}\dot{\lambda} - (\nabla\lambda)(\nabla\lambda)]$$

Variation of λ

$$(\frac{\partial}{e^{\lambda}\partial t})(\frac{\partial}{e^{\lambda}\partial t})\lambda - \nabla^2\lambda = RHS$$

For stationary fields, one then gets the simple equation

$$\nabla^2\lambda = RHS$$

For empty space, one gets the Coulomb potential

$\lambda = +- 1/R$

and the only divergence is at R = 0 as one could expect.
The sign depends, of course, on the coupling constant and the energy content at the center.
This is entirely reasonable.
It is, of course, dissatisfying to derive field equations in a lopsided frame that is not even Lorentz-invariant.
(One would have to construct the Synchronized Frame first, then do a Lorentz boost, then go back to the new IF)

(As a matter of fact, the equation in the IF is not *that* different from the SF-case, which can be brought into the same form with a coordinate transformation. The transformation assumes well-behaved functions and loses the details of the rigorous solution.)

Epilog

We have derived a number of gravitational effects from the scalar mass field.
But - the purpose of this paper is *not* to cook up and sell a new theory of gravity.
The purpose of this paper is purely didactical:
when you introduce ad-hoc fields on a fundamental level, *watch out for the consequences!*